United Nations A/AC.105/777

General Assembly

Distr.: General
18 December 2001

Original: English

Committee on the Peaceful Uses of Outer Space

Obtrusive space advertising and astronomical research

Background paper by the International Astronomical Union

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V.01-89939 (E) 090102 100102

I. Introduction

1. In its resolution 56/51 of 10 December 2001, paragraph 15 (c), the General Assembly endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space that the Committee's Scientific and Technical Subcommittee consider the issue of international cooperation in limiting obtrusive space advertising that could interfere with astronomical observations at its thirty-ninth session. At its thirty-eighth session, the Scientific and Technical Subcommittee agreed that space-related scientific organizations such as the International Astronomical Union (IAU) should be invited to conduct a background study on the subject and present the results to the Subcommittee to facilitate its work (A/AC.105/761, annex II, para. 19).

2. The present background paper by the International Astronomical Union has been submitted in response to this request.

II. Background

3. Astronomy is one of the oldest fascinations of the human mind. From the dawn of humanity, humans have contemplated the sky and the motions of the heavenly bodies. Their studies of the Sun and Moon gave us the calendar: the day, the month, the seasons, and the year, which govern short- and long-term survival and prosperity in cultures based on hunting or farming. Astronomy thus became not only a practical tool, but also a key element in the organizational and religious structure of many civilizations throughout human history.

4. The intricate motions of the planets in the sky were also charted already thousands of years ago, providing both the motivation and the foundation for the drive to understand the structure of the universe as it was then understood, i.e. the solar system. The path towards this goal led directly to the discovery of the law of gravitation, the finite speed of light, and the dynamical consequences of general relativity—cornerstones of modern science. Pursuing the quest towards ever more distant horizons eventually led to the modern, grand and richly detailed physical picture of the cosmic evolution which led from the birth of the universe to that of mankind. Yet, the recent discovery of other planetary systems—very different from our own—serves to remind us that vast scientific horizons still remain unexplored.

5. Along this intellectual journey, astronomy has been instrumental in shaping modern empirical science, based on reproducible measurements and verifiable physical laws. Unable to experiment with their objects of study, astronomers must rely on observations of ever-increasing sophistication, diversity and sensitivity. Today, objects in the farthest reaches of the universe are being studied at all wavelengths of the electromagnetic spectrum, from gamma and X-rays via visible and infrared light to radio waves. Front-line telescopes and detectors on the ground and in space routinely study objects that are 100 million times fainter than any visible with the naked eye, and all the energy collected by the world's radio telescopes in the 50-year lifespan of radio astronomy would only suffice to light a flashlight bulb for a fraction of a second. Yet the key questions of cosmology require continued progress in sensitivity, and no fundamental limit is in sight.

III. Environmental impacts on astronomy

6. Astronomical observations are made against a background of natural and artificial signals. The faintest galaxies now studied are only about one per cent as bright as the natural light of even the darkest night sky, due about equally to atmospheric airglow and sunlight scattered by dust in the solar system. Radio observations of such faint galaxies are made against a radio background from such sources as the Sun, Jupiter, and the centre of the Milky Way. Careful choices of wavelength ranges and sophisticated observational techniques normally allow these natural obstacles to be overcome.

7. Unfortunately, human-induced degradation of the environment has made astronomical observations at all wavelengths increasingly difficult in recent decades. Ground-based light pollution has increased to the point where 90 per cent of the population of the United States of America or the European Union lives under a sky that is at least twice its natural brightness, according to the recent "First world atlas of the artificial night sky brightness".[1] Two thirds of the populations of these regions never see a sky darker than a full-moon night, which makes deep-sky astronomy impossible, and half have already lost naked-eye visibility of the Milky Way. Many developing countries are similarly affected.

8. In the radio domain, developments have been no less dramatic: If one of today's ubiquitous mobile

telephones were placed on the Moon, it would be among the four brightest sources in the radio sky, and the cosmic sources studied in front-line research are millions of times fainter than this. Radio astronomers are being denied access to increasing parts of the electromagnetic spectrum, also because unwanted emissions from other users spill into bands reserved for radio astronomy by the International Telecommunication Union, overwhelming the vastly fainter astronomical signals.

9. For over a century, astronomers have acted to avoid these disturbances by moving both optical and radio observatories into increasingly remote regions of the world. The symptoms of economic progress have followed them there, but agreements with enlightened national Governments and local authorities have often created a harmonious coexistence between the astronomers and the local population. For example, reducing (electric) light pollution plainly saves money as well as facilitating the progress of science—a true win-win situation.

10. However, the increasing activity in outer space has caused a qualitative change in the environmental conditions for astronomy. Scattered light from sunlit spacecraft and space debris, and radio noise from communications satellites and global positioning systems in space, reach the entire surface of the Earth. No place is sheltered from these disturbances, and a pristine sky is no longer to be found anywhere on Earth, including developing countries. Already, this loss is irreversible.

11. Astronomers are seeking support to limit the rate of growth of this pollution of the sky. The odds are daunting, inasmuch as the actions of any player in space may affect astronomy throughout the world, and deregulation and privatization of space services complicate the regulatory situation considerably. Yet, international agreements have been successfully negotiated to limit environmental problems with even greater financial and political implications than those of astronomy.

IV. Advertising in space

12. Advertising is among the activities with potentially adverse effects on the space environment. The tremendous qualitative difference from traditional forms of advertising is that no nations or individuals can refuse to be exposed to space advertising, which might be considered undesirable for scientific, aesthetic, political, or even religious reasons. As advertising is generally intended to enhance the profits of an enterprise, this may be viewed as an advantage of space advertising, but it is hardly an activity conducted "for the benefit of all mankind", and its potential adverse effects should be weighed accordingly.

13. Advertising on radio and television is already being distributed from broadcasting satellites in space. Although ubiquitous, it can still be avoided by turning off receivers at home or by visiting national parks or similar reserves. In contrast, the visible light from obtrusive advertising, defined as "advertising in outer space that is capable of being recognised by a human being on the surface of the Earth without the aid of a telescope or other technological device",[2] is inescapable. Once in place it imposes on all and, depending on its orbital characteristics, may do so for thousands of years.

14. In fact, most space advertising is likely to greatly outlast the enterprise that launched it, unless end-of-mission deorbiting procedures are required and implemented. Moreover, because space objects used for advertising purposes need to be very large, they also present a large cross-section to impacts of existing space debris, resulting in the creation of even more such debris.

V. Obtrusive space advertising projects in the past

15. The last two decades have seen a number of projects that were clearly in the category of obtrusive space advertising. Even more projects have appeared which were marketed as artistic, celebratory, or technological feasibility projects, but the true nature of which proves to be advertising upon closer examination. A number of these are briefly described below. From the viewpoint of astronomy, it is a fortunate fact that none of these projects was actually implemented as planned, due to technical failures or lack of political and/or financial support. Thus, there still remains time to act before the world finds itself with a fait accompli.

16. The potentially most devastating proposal for a clear-cut space advertising project, by Space Marketing Inc. (Georgia, United States), was aptly named the "Space Billboard". About one square kilometre in dimension, it would have rivalled the full Moon in size and brightness. "Obtrusive" is a fitting description indeed, and when visible it would have obliterated most astronomical

observations. Moreover, it was estimated to receive some 10,000 impacts of space debris per day, with associated debris proliferation. A project for a similar reflector of 1,000 x 400 m size was proposed for the Olympic Games in Atlanta in 1996. In the end, however, none of these projects were able to attract the required funding.

17. Space objects that would have provided even brighter illuminations (some ten times that of the full Moon) were the Russian solar reflectors Znamya 2 and 2.5. These large deployable mirrors were intended to provide winter illumination in polar regions. Yet, the demonstration flights in 1993 and 1999 would have illuminated a number of cities in Europe and the United States and would thus have served primarily to advertise the system itself. However, both attempts to unfold the mirrors failed, so the performance of the system was never verified in practice. But proponents of even larger space solar power projects remain active worldwide.

18. Smaller-scale projects were proposed which formally had celebratory purposes, but with strong implicit elements of advertising. "The Ring of Light" was a French project to launch a ring of bright satellites to celebrate the bicentennial of the revolution and the centennial of the Eiffel Tower in 1989. The "Star of Tolerance" (also French), a pair of very large tethered balloons in low orbit which would have become as bright as Venus at maximum, was formally intended to celebrate the fiftieth anniversary of the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1999, but was in reality a thinly disguised space advertising enterprise. In the end, both projects were abandoned after vigorous international opposition.

19. A final example of space advertising presented under another label is the project initiated in the 1980s by the Celestis Corporation (Florida, United States) to launch cremated human remains into space in shining cylinders. The project was delayed due to a conflict with local Florida legal regulations, but continued later through launches from California. Fortunately, the project has been modified so that capsules with cremated remains are not dispersed into space, but stay fixed inside the last stage of the satellite launcher. However, the orbital lifetime of these stages at circular orbits between 600 to 900 kilometres is relatively long. So far, there have been three successful launchings into Earth orbit (21 April 1997, 10 February 1998 and 21 December 1999). The latest attempt on 21 September 2001 was unsuccessful and the next launch is scheduled for mid-2002.

VI. Obtrusive space advertising: general considerations

20. It will appear from these examples that whereas the term "obtrusive" is clear and unambiguous, the definition of "advertising" is far from obvious. Certainly, the formal purpose of a project as stated by its originators is not an adequate criterion. However, the projects mentioned above, whether or not their true purpose was explicitly advertised, share two characteristics. First, they had no factual scientific or technical function such as telecommunications, observations of Earth or space, apart from attracting the attention of people on Earth. Second, the flow of revenues would go only to the originators of the project. It would appear that the combination of these two characteristics might form the nucleus of an internationally agreed definition of space advertising.

21. It is noted that no definitions of "obtrusive space advertising" would include the usual agency or company logos on spacecraft (which are not visible from the ground), nor such space vehicles as telecommunications satellites, even if they may be commercial projects and disseminate advertising from space.

22. It is also noted that "obtrusive space advertising" by no means encompasses all artificial space objects which have a negative impact on astronomy. A large number of spacecraft already in orbit and launched for a wide variety of purposes are sufficiently bright to have a damaging effect on astronomical observations in that region of the sky, the International Space Station being the most prominent example. For the purposes of this discussion, it will be assumed that their benefit to national or international interests is perceived to outweigh their adverse effects.

VII. Obtrusive space advertising: astronomical classification

23. The severity of the impacts of obtrusive space advertising may be classified according to a few basic characteristics of the corresponding space object:

(a) Brightness as seen from the surface of the Earth;

(b) Time of visibility from a given observing point on Earth;

(c) Extent and positional control of the illuminated area on Earth.

24. The brightness of a space object as seen from a ground-based observatory is clearly the main parameter determining its impact on the observations. Essentially, any object that is visible with the naked eye will ruin an astronomical observation conducted in the same direction. For the faintest, fast-moving objects, recovery may be possible through multiple exposures and digital filtering, as is already necessary to cope with existing satellites and space debris. However, the brightest such objects—as bright as or brighter than Venus or Jupiter—may damage the ultra-sensitive detector systems used on large telescopes. Protection of large telescopes by separate monitoring of the field for bright moving objects may soon become necessary.

25. In contrast, any object of a brightness comparable to the full Moon will, like the real Moon, generate so much scattered light in the Earth's atmosphere that observations of all faint objects become impossible. Whether or not such a disturbance would spell the end of ground-based observational cosmology depends on the temporal and geographical extent of the illumination. Space observatories would be immune to only some of this type of pollution, but are also so costly and specialized that the future of astronomy cannot be based on space observatories alone.

26. The fraction of night-time in which an object is visible is another key parameter. Objects which are visible and/or bright only in evening or morning twilight are generally less detrimental to astronomy than objects which remain visible all night. Importantly, however, observations of other sunlit objects, such as near Earth asteroids inside the Earth's orbit or space debris, must also be done at twilight and would suffer directly from a proliferation of bright objects at that time.

27. From a practical point of view, the most economical way to create a luminous object in the sky is to launch a highly reflecting surface in low orbit. The brightness and visibility of the object can be enhanced by increasing its size and optimizing its surface properties. The limitations of this type of illumination to the twilight hours can be alleviated by raising the object to a higher orbit, well out of the Earth's shadow, and/or by installing artificial illumination on the spacecraft. Both of these techniques raise the complexity and cost of the experiment considerably.

28. Finally, the size and position of the illuminated area are of importance. If an object illuminates the entire dark hemisphere of the Earth, all night-time astronomy suffers in proportion to the brightness of the illumination. However, some experiments are intended to intensify the illumination by focusing it, through the use of mirrors, onto a geographical area of limited size. Hence, if control could be maintained over the position of this area, astronomical observatories and other sensitive sites, such as national parks, could in principle be kept free of unwanted illumination. However, first, this would require precise on-board control mechanisms for the mirrors, including fallback systems in case of malfunctions. Second, there remains the issue of a suitable international mechanism to define the protected sites and enforce the regulations.

VIII. Previous international efforts to protect astronomy

29. As the main international scientific organization in the field of astronomy, IAU has made sustained efforts to call attention to the deterioration of the environment and its effects upon the future of astronomy. The general assemblies of IAU, held every three years, have for forty years in their resolutions advocated measures to prevent adverse space activities in either the optical or the radio region, or both. The pollution of the sky affects astronomy in developing and developed countries alike, and IAU serves as the international advocate for astronomy throughout the world.

30. In fact, as early as 1961, the IAU General Assembly "viewed with great concern the grave danger that some future space project might seriously interfere with astronomical observations in the optical as well as in the radio domain" and "appealed to all Governments to refrain from launching [such projects] until it is established beyond doubt that no danger will be done to astronomical research". In 1970, the IAU General Assembly recalled and reaffirmed this resolution, referring specifically to the United Nations Outer Space Treaty,[3] in particular to its articles IV and IX, a stand that was repeated and re-emphasized in following years.

31. Notwithstanding, problems continued to increase and the twentieth IAU General Assembly in 1988 appealed to the International Council of Scientific Unions (ICSU) and its Scientific Committee on Problems of the Environment (SCOPE) to take up this aspect of the

general problem of the degrading environment. A special meeting, IAU Colloquium 112, Light Pollution, Radio Interference, and Space Debris,[4] was also held to discuss and highlight the specific problems and outline suitable countermeasures. This was followed up again in 1992 by the high-level International Symposium on the Adverse Environmental Impacts on Astronomy, organized jointly by IAU, ICSU, UNESCO and the Committee on Space Research (COSPAR), and resulting in the volume *The Vanishing Universe*[5] in which, for the first time, specific high-level strategic goals were defined and a plan for pursuing them was laid out.

32. As one initiative resulting from the 1992 conference, IAU applied for status as Permanent Observer with the United Nations Committee on the Peaceful Uses of Outer Space. This was granted in 1994, and subsequent IAU efforts have been made in cooperation with the Committee. Thus, a Technical Forum, the International Astronomical Union/Committee on Space Research/United Nations Special Environmental Symposium "Preserving the Astronomical Sky",[6] was organized in conjunction with the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) in 1999. The meeting presented its recommendations[7] to the main Conference, and the Space Millennium: Vienna Declaration on Space and Human Development adopted by UNISPACE III contains corresponding policy guidelines for future activities in space "before further irreversible actions are taken affecting future utilization of near-Earth space or outer space".[8] These recommendations apply also to obtrusive space advertising.

IX. Policy recommendations

33. The future of astronomy clearly depends on the extent to which it will be possible to limit the degradation of the space environment. Obtrusive space advertising is one such grave concern for the future. Unlike several other forms of adverse environmental impact, however, there is still time for prevention before irreversible damage to astronomy is done.

34. IAU therefore appreciates and applauds the measures taken by the United States of America to prohibit the granting of a launch licence to any form of such advertising.[2] As outlined above, this measure alone will by no means guarantee that astronomy will be free of interference from activities in space, be it in the optical or in the radio domain. But prohibiting space advertising that would be visible by the vast majority of the world's population will undoubtedly greatly reduce the financial incentive to engage in such projects. This initiative should therefore be followed up by other spacefaring nations.

35. Accordingly, IAU recommends for the consideration of the Committee on the Peaceful Uses of Outer Space:

(a) That Member States should be encouraged to adopt similar legislation on obtrusive space advertising, so that this activity is regulated by all space-faring nations;

(b) That international guidelines to limit the environmental impact of space activities on astronomy be developed by the Committee, in close cooperation with IAU, to ensure that uniform principles are applied to the definition of projects to which this legislation would apply.

Notes

[1] P. Cinzano, F. Falchi and C. D. Elvidge, *Monthly Notices of the Royal Astronomical Society*, vol. 328 (2001), pp. 689-704.

[2] United States code, title 49, chap. 701, sect. 70109a.

[3] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (General Assembly resolution 2222 (XXI) of 19 December 1966).

[4] D. L. Crawford, ed., *Light Pollution, Radio Interference, and Space Debris (IAU Colloquium 112)*, conf. series 17 (San Francisco, Astronomical Society of the Pacific, 1991).

[5] D. McNally, *The Vanishing Universe* (Cambridge University Press, 1994).

[6] R. J. Cohen and W. T. Sullivan, III, eds., *Preserving the Astronomical Sky (IAU Symposium 196)* (Astronomical Society of the Pacific, 2001).

[7] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), annex III, chap. II.

[8] Ibid., chap. I, resolution 1, para. 1 (c) (v).